NASA: Engineering Space Exploration

National Aeronautics and Space Administration

Launching to the Moon, Mars, and Beyond

Presented to The Auburn Chapter of the American Institute of Aeronautics and Astronautics, September 30, 2008 Auburn University, AL

C. Herbert Shivers, PhD, PE, CSP

Deputy Director, Safety and Mission Assurance Directorate

NASA/Marshall Space Flight Center

What is NASA's Mission?

- Safely fly the Space Shuttle until 2010
- Complete the International Space Station
- Develop a balanced program of science, exploration, and aeronautics
- Develop and fly the Orion Crew Exploration Vehicle (CEV)
- Return to the Moon no later than 2020
- Promote international and commercial participation in exploration

"The next steps in returning to the Moon and moving onward to Mars, the near-Earth asteroids, and beyond, are crucial in deciding the course of future space exploration. We must understand that these steps are incremental, cumulative, and incredibly powerful in their ultimate effect."

– NASA Administrator Michael Griffin
October 24, 2006

Spacelab J - Huntsville and Decatur

Auburn 6

Alabama 1

WIIFM?

- **State of Alabama**
  - 150,000 aerospace industry workers in the state
    - $6.16 billion annual payroll
    - Third highest average annual wage in the Nation behind VA and CA
- **Huntsville, Al**
  - 430 aerospace companies
  - Home to Redstone Arsenal
    - RSA – 8 major commands – soon 11 General Officers
    - 30,000 people come on site at Redstone each day
    - More than $35 billion in Federal procurements each year
  - Home to Marshall Space Flight Center
    - $2 billion annual budget
    - About 2500 Civil Service employees
    - About 5000 contractor employees
  - Need all disciplines of engineers
  - 2000 - 20,000 new jobs over the next five years (BRAC)
  - Baby Boomers are retiring – outnumber Gen X about 3 to 1

NASA Engineers

- Number of Civil Service Engineers (as of August 2007)
  - NASA – 9563
    - Johnson Space Center – 2230
    - Marshall Space Flight Center – 1650
    - Kennedy Space Center – 1264
    - Goddard Space Flight Center – 1414

- Disciplines
  - Systems, Safety, Fire Protection, Materials, Architect, Civil, Environmental, Mechanical, Nuclear, Electrical, Computer, Electronics, Biomedical, Aerospace, Agricultural, Ceramic, Chemical
- Probably 3 to 4 times this number of contractor engineers

MSFC LEGACY

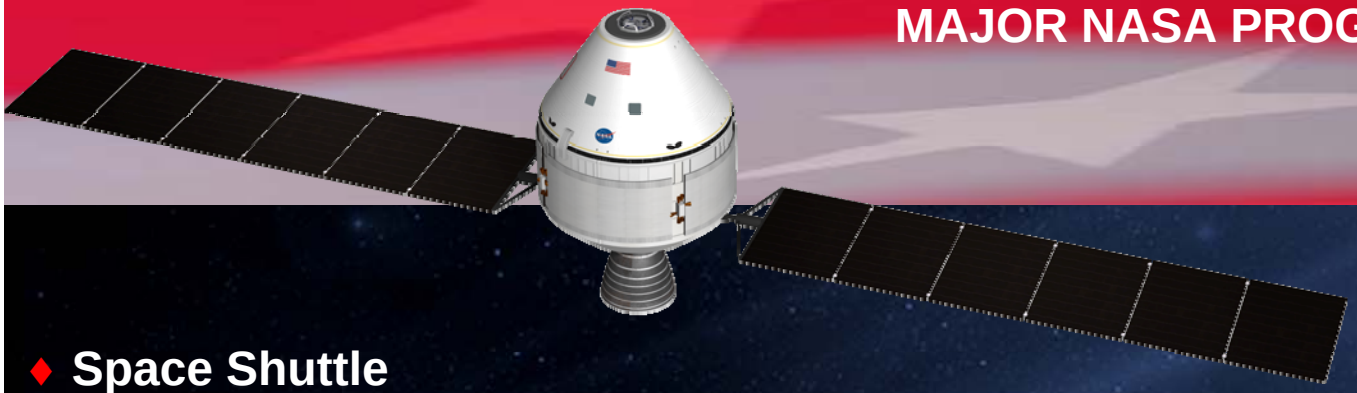
Today's Journey

- What is NASA's mission?
- Why do we explore?
- What is our timeline?
- Why the Moon first?
- What will the vehicles look like?
- What progress have we made?
- Who will be doing the work?
- What are the benefits of space exploration?

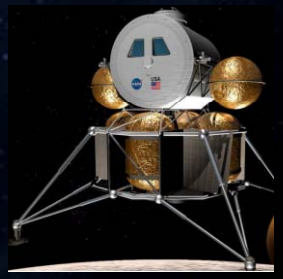
Why Do We Explore?

- **Inspiration**
  - Inspire students to explore, learn, contribute to our nation's economic competitiveness, and build a better future
- **Innovation**
  - Provide opportunities to develop new technologies, new jobs, and new markets
- **Discovery**
  - Discover new information about ourselves, our world, and how to manage and protect it

MAJOR NASA PROGRAMS

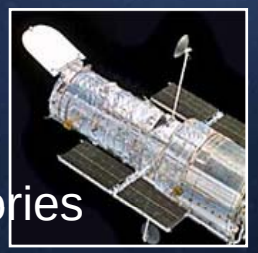


- **Space Shuttle**
- **International Space Station**
- **Earth and Space Sciences**
- **Constellation Program**
  - Crew Launch Vehicle
  - Cargo Launch Vehicle
  - Crew Exploration Vehicle
  - Crew Service Module
  - Earth Departure Stage
  - Altair Lunar Lander
  - Mars Transfer Vehicle
  - Mars Descent/Ascent Vehicle
- **Lunar Precursor Robotic Program**
  - Lunar Reconnaissance Orbiter (LRO)
  - Lunar Crater Observation and Sensing Satellite (LCROSS)



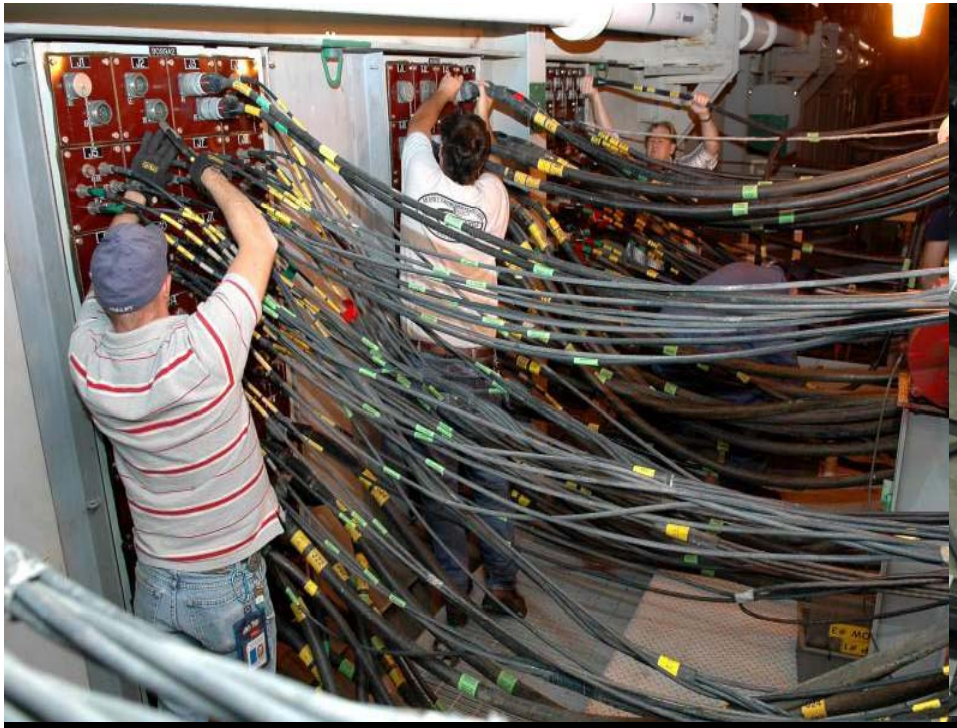
Earth and Space Sciences

- SERVIR
  - A system that helps scientists and authorities in southern Mexico and Central America identify sudden changes in environmental conditions, mapping details of deforestation, forest fires, hurricanes and toxic algae red tides
  - Beginning applications in Africa



- Hubble Space Telescope
  - The visible/ultraviolet/near-infrared element of the Great Observatories astronomical program.
  - STS 125 is the final servicing mission to HST
  - Extend its life and increase capabilities
- Other Space Telescopes – Spitzer, Chandra, James Webb (2013)

Shuttle Processing




United States
Discovery

Rare Site – Two Shuttle on Pads
October 20, 2008

International Space Station

♦ISS Assembly Sequence

NASA's Exploration Roadmap

05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25…

Exploration and Science Lunar Robotics Missions

Lunar Outpost Buildup

Mars Expedition ~2030

Research and Technology Development on ISS

Commercial Orbital Transportation Services for ISS

Space Shuttle Operations

SSP Transition

Ares I and Orion Development

Operations Capability Development
(EVA Systems, Ground Operations, Mission Operations)

Ares I-X Test Flight April 2009

Orion and Ares I Production and Operation

Altair Development

Ares V & Earth Departure Stage

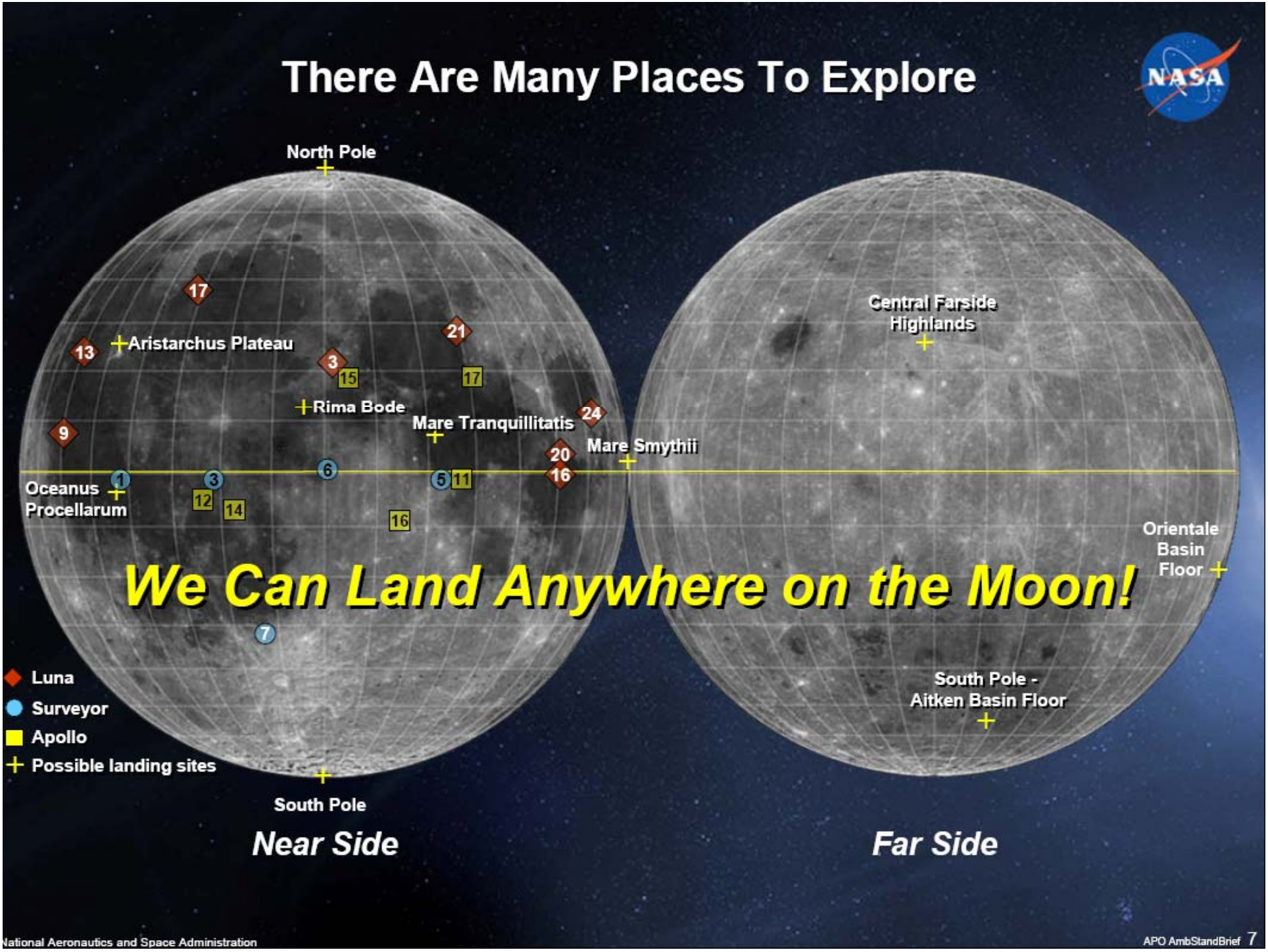
Surface Systems Development

The Moon

- **Lunar missions allow us to:**
  - Gain exploration experience
    - Space no longer a short-term destination
    - Will test human support systems
    - Use Moon to prove ability to build and repair long-duration space assets
  - Develop exploration technologies
    - Launch and exploration vehicles
    - *In-situ* resource utilization
    - Power and robotic systems
  - Conduct fundamental science
    - Astronomy, physics, astrobiology, geology, exobiology

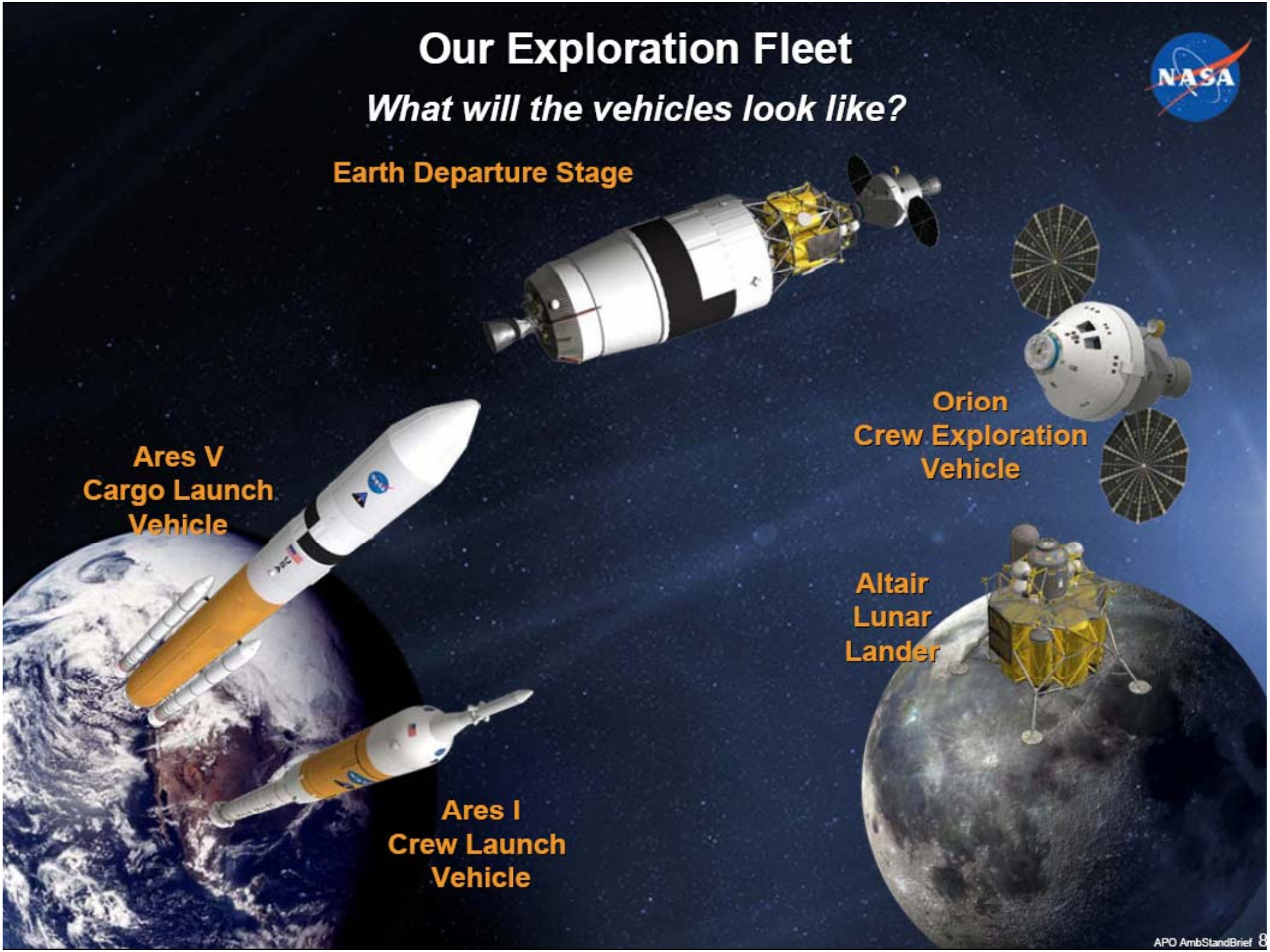
Next Step in Fulfilling Our Destiny as Explorers

There Are Many Places To Explore



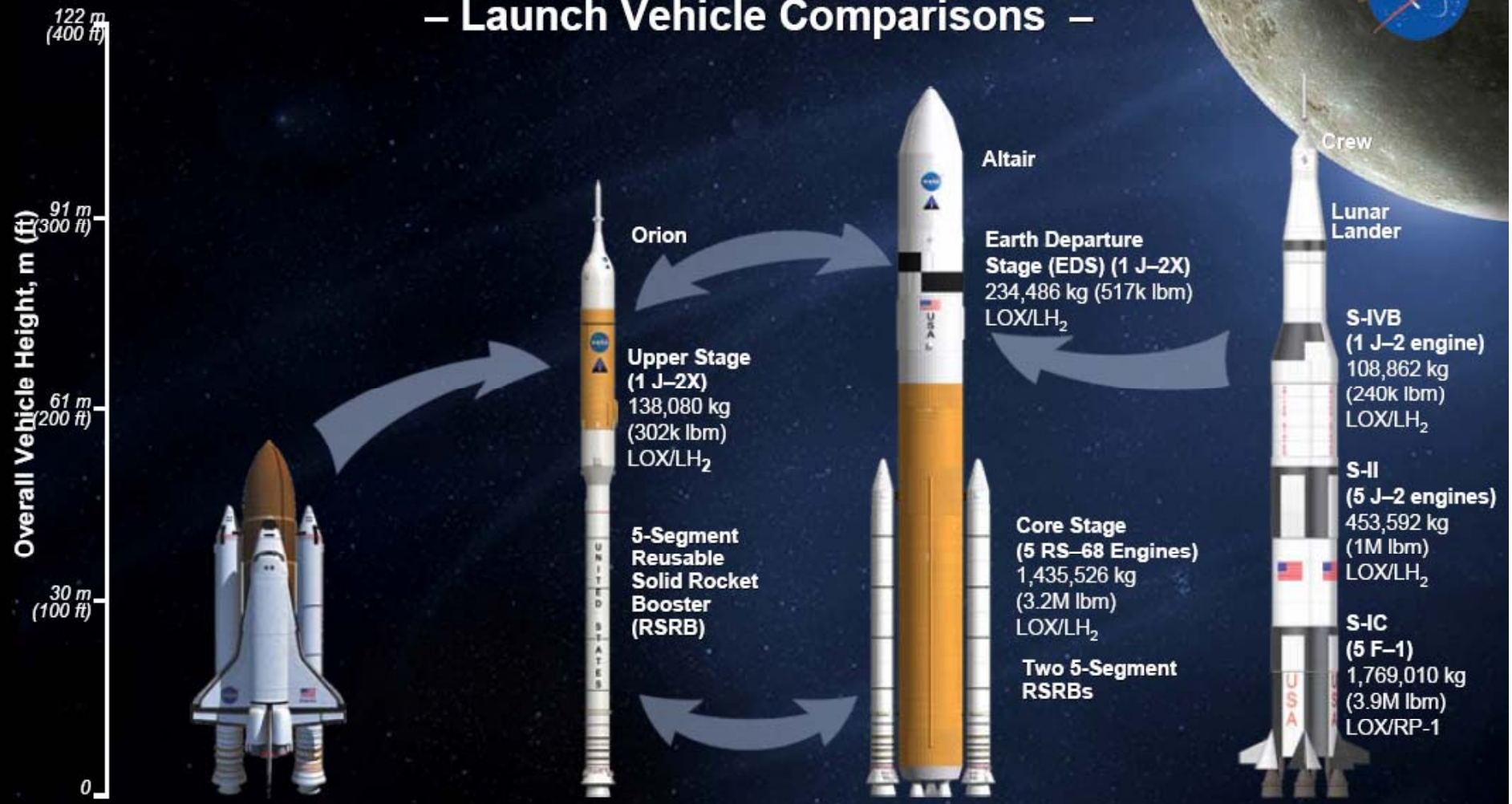
Our Exploration Fleet

What will the vehicles look like?



Journey to the Moon

Building on a Foundation of Proven Technologies
– Launch Vehicle Comparisons –



Space Shuttle
Height: 56.1 m (184.2 ft)
Gross Liftoff Mass:
2,041,166 kg (4.5M lbm)

25 MT (55k lbm)
to Low Earth Orbit (LEO)

Ares I
Height: 99.1 m (325 ft)
Gross Liftoff Mass:
927,114 kg (2.0M lbm)

25.6 MT (56.5k lbm)
to LEO

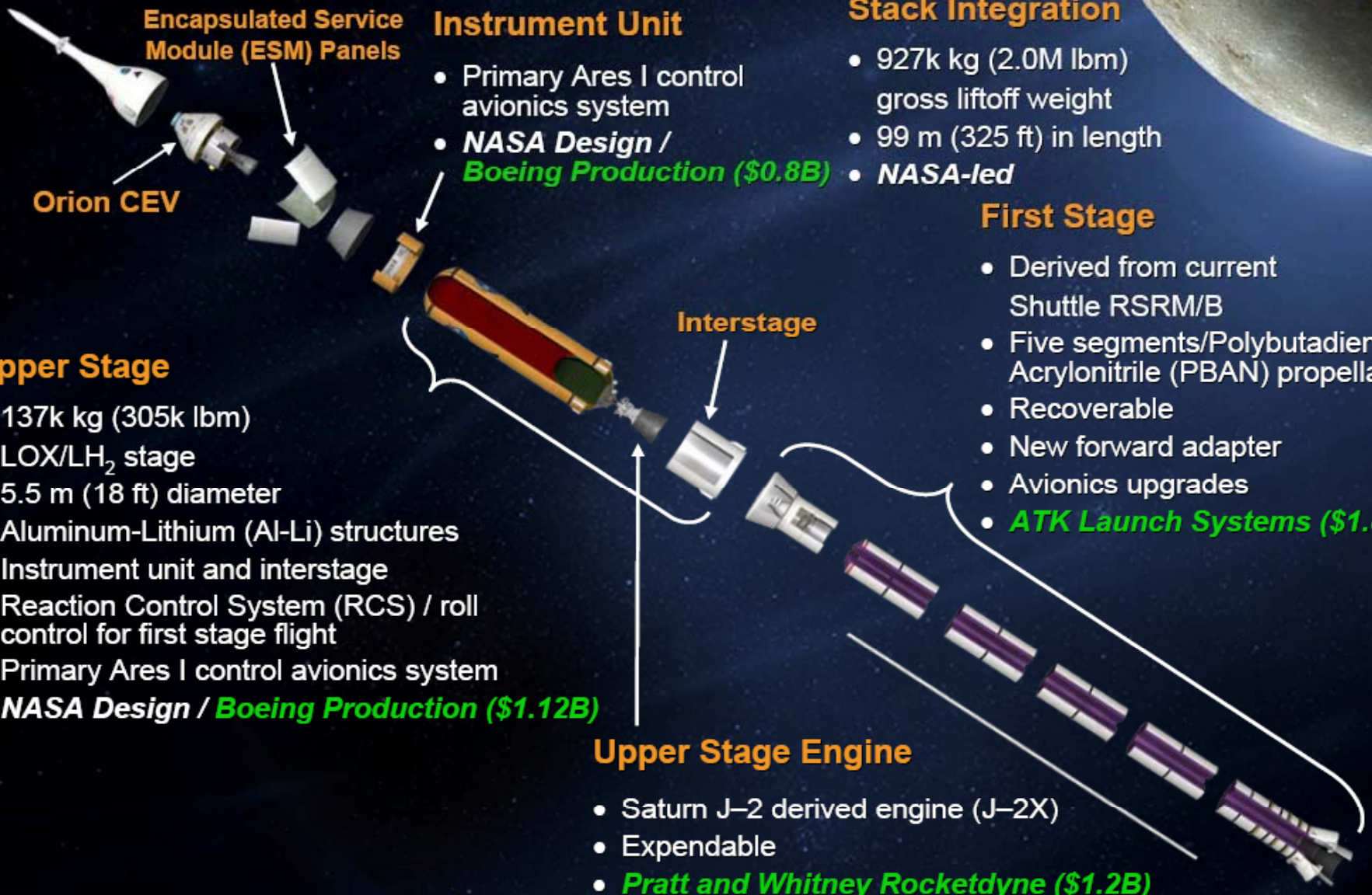
Ares V
Height: 109.7 m (360.5 ft)
Gross Liftoff Mass:
3,374,875 kg (7.4M lbm)

63.6 MT (140.2k lbm) to TLI (with Ares I)
55.9 MT (123k lbm) to Direct TLI
~143.4 MT (316k lbm) to LEO

Saturn V
Height: 110.9 m (364 ft)
Gross Liftoff Mass:
2,948,350 kg (6.5M lbm)

45 MT (99k lbm) to TLI
119 MT (262k lbm) to LEO

Ares I Elements



Instrument Unit

- Primary Ares I control avionics system
- ***NASA Design / Boeing Production ($0.8B)***

Stack Integration

- 927k kg (2.0M lbm) gross liftoff weight
- 99 m (325 ft) in length
- ***NASA-led***

First Stage

- Derived from current Shuttle RSRM/B
- Five segments/Polybutadiene Acrylonitrile (PBAN) propellant
- Recoverable
- New forward adapter
- Avionics upgrades
- ***ATK Launch Systems ($1.8B)***

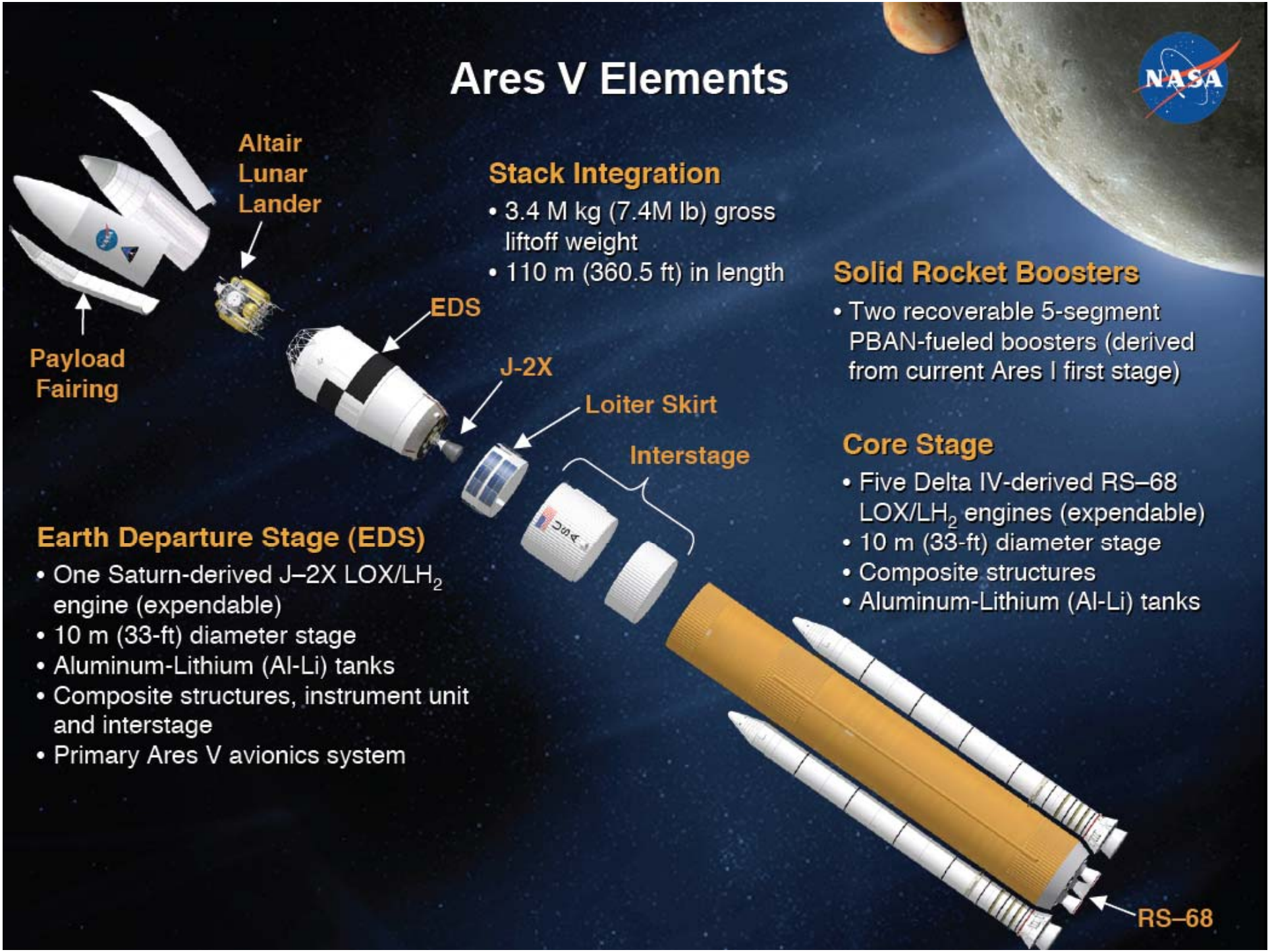
Upper Stage

- 137k kg (305k lbm) LOX/LH_2 stage
- 5.5 m (18 ft) diameter
- Aluminum-Lithium (Al-Li) structures
- Instrument unit and interstage
- Reaction Control System (RCS) / roll control for first stage flight
- Primary Ares I control avionics system
- ***NASA Design / Boeing Production ($1.12B)***

Upper Stage Engine

- Saturn J–2 derived engine (J–2X)
- Expendable
- ***Pratt and Whitney Rocketdyne ($1.2B)***

Ares V Elements



Stack Integration

- 3.4 M kg (7.4M lb) gross liftoff weight
- 110 m (360.5 ft) in length

Solid Rocket Boosters

- Two recoverable 5-segment PBAN-fueled boosters (derived from current Ares I first stage)

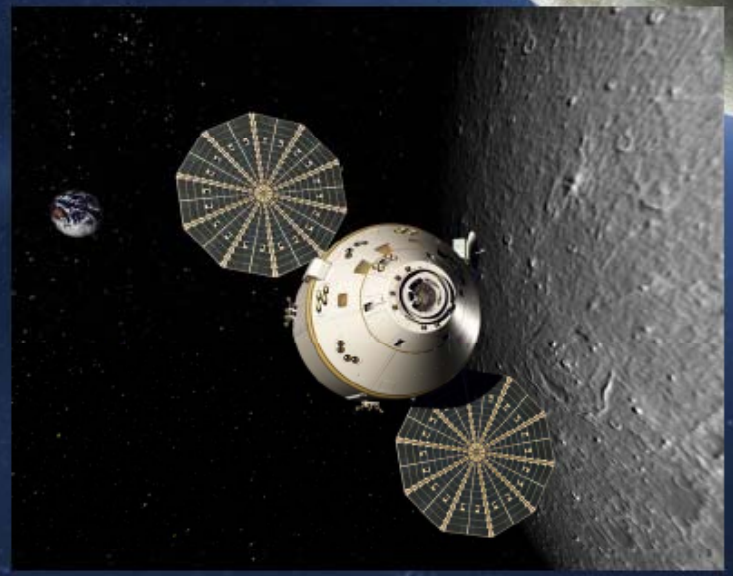
Core Stage

- Five Delta IV-derived RS–68 LOX/LH_2 engines (expendable)
- 10 m (33-ft) diameter stage
- Composite structures
- Aluminum-Lithium (Al-Li) tanks

Earth Departure Stage (EDS)

- One Saturn-derived J–2X LOX/LH_2 engine (expendable)
- 10 m (33-ft) diameter stage
- Aluminum-Lithium (Al-Li) tanks
- Composite structures, instrument unit and interstage
- Primary Ares V avionics system

Orion Crew Exploration Vehicle



Launch Abort System

Attitude Control Motor
(Eight Nozzles)

Canard Section
(Stowed Configuration)

Jettison Motor
(Four Aft, Scarfed Nozzles)

Abort Motor
(Four Exposed, Reverse Flow Nozzles)

Crew Module

Service Module

LOCKHEED MARTIN

Encapsulated Service Module (ESM) Panels

Spacecraft Adapter

Volume: 10.8 m^3 (380 ft^3)
- 80% larger than Apollo

Diameter: 50 m (16.5 ft)

- **First full-scale rocket motor test for the Orion spacecraft**
  - Test of a solid rocket that will be used to jettison the craft's launch abort system
  - Separates the craft's launch abort system from the Orion crew module during launch
  - The Orion launch abort system is a larger solid rocket motor system that will provide a safe escape for the crew in an emergency on the launch pad or during the climb to orbit
  - Completed March 2008

What progress have we made?

- Programmatic Milestones Completed
  - Ares 1 Systems Requirements Review
  - Ares 1 Systems Definition Review
  - Ares 1 Preliminary Design Review
  - Contracts awarded for first stage, J-2X engine, upper stage, instrument unit, and Orion
  - Ares 1-X test flight scheduled for Spring 2009
- **Technical Accomplishments**
  - First stage parachute tests
  - Developing first stage nozzles
  - J-2X test stand construction at Stennis Space Center
  - J-2x injector and power pack tests
  - Fabricating Ares 1-X hardware
  - Wind tunnel tests

Nozzle Process Simulation Article

Powerpack 1A Testing

Dome Gore Panel Fabrication

"Roughing" of 1% Model

go to www.nasa.gov/ares

What progress have we made?

For more information go to www.nasa.gov/ares

Ares I–X Test Flight

- **Demonstrate and collect key data to inform the Ares I design:**
  - Vehicle integration, assembly, and launch operations
  - Staging/separation
  - Roll and overall vehicle control
  - Aerodynamics and vehicle loads
  - First stage entry dynamics for recovery

- **Performance Data:**

	Ares I–X	Ares I
First Stage Max. Thrust (vacuum):	14.1M N (3.13M lbf)	15.8M N (3.5M lbf)
Max. Speed:	Mach 4.7	Mach 5.84
Staging Altitude:	39,624 m (130,000 ft)	57,453 m (188,493 ft)
Liftoff Weight:	834k kg (1.8M lbm)	927k kg (2.0M lbm)
Length:	99.1 m (327 ft)	99 m (325 ft)
Max. Acceleration:	2.46 g	3.79 g

Ares Nationwide Team

ATK Launch Systems

Marshall

Glenn

Ames

Langley

Pratt & Whitney Rocketdyne

Kennedy

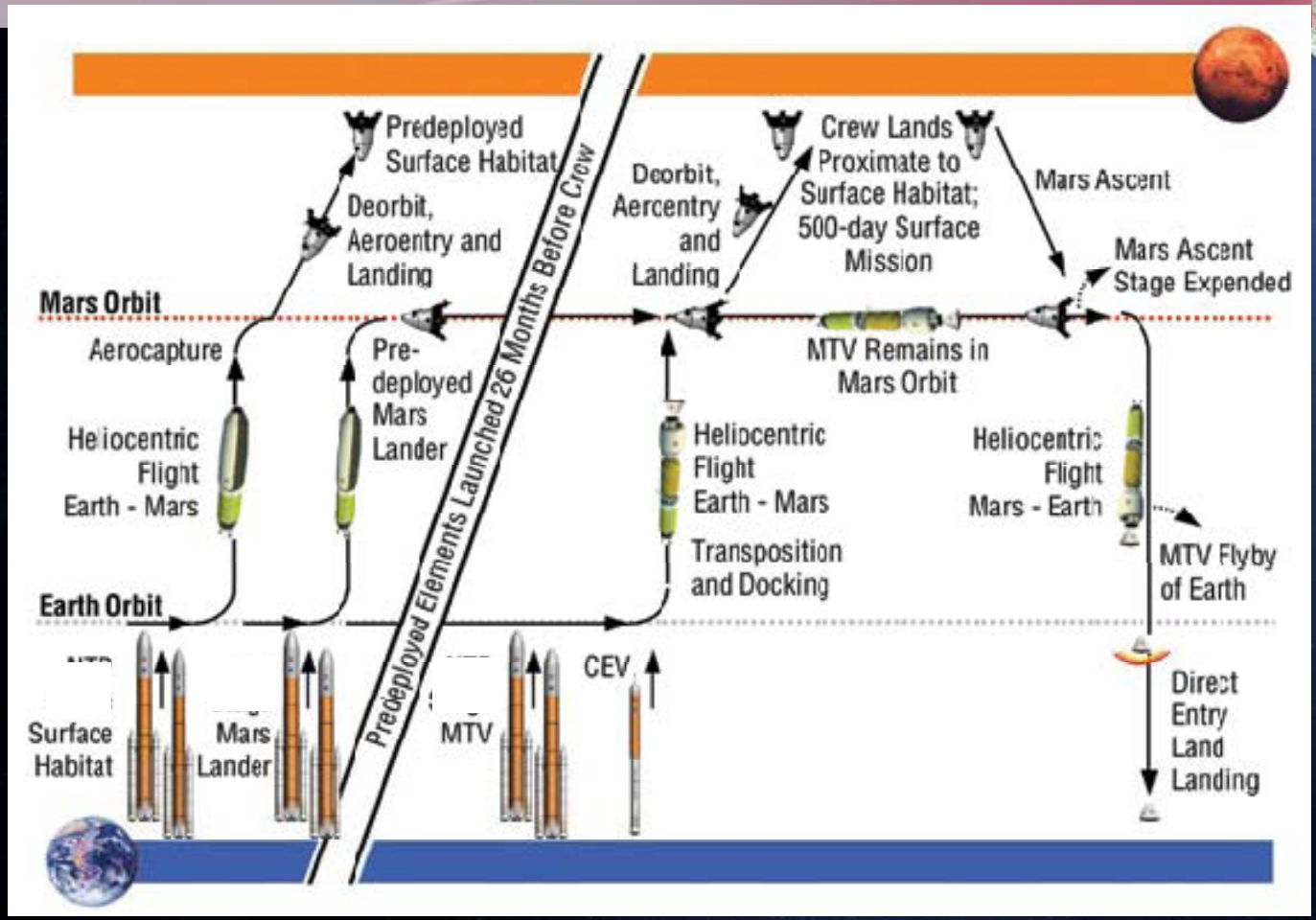
Johnson

Michoud Assembly Facility

Stennis

Boeing

Concept - MARS Mission

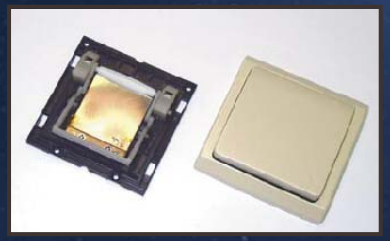


Transfer to and from Mars in about 6 months – Mars surface stay about 18 months. Each human mission to Mars is comprised of three vehicle sets, two cargo vehicles, and one round-trip piloted vehicle. Planned 2.5-year mission

Down-to-Earth Benefits from the Space Economy

NASA powers innovation that creates new jobs, new markets, and new technologies

- **Personal Health**
  - Eye tracker for LASIK surgery
  - Breast biopsy system
  - 3D Imaging for surgery
- **Consumer Products**
  - Wireless light switch
  - Remote appliance programmer
  - Global Positioning Systems (GPS)
- **Environmental**
  - Water Filtration system
  - Environmentally friendly chemical cleanup
- **Security**
  - Stair-climbing tactical robot
  - Crime scene video enhancement



For more information see http://technology.jsc.nasa.gov

Every Dollar Invested in Space is Spent on Earth

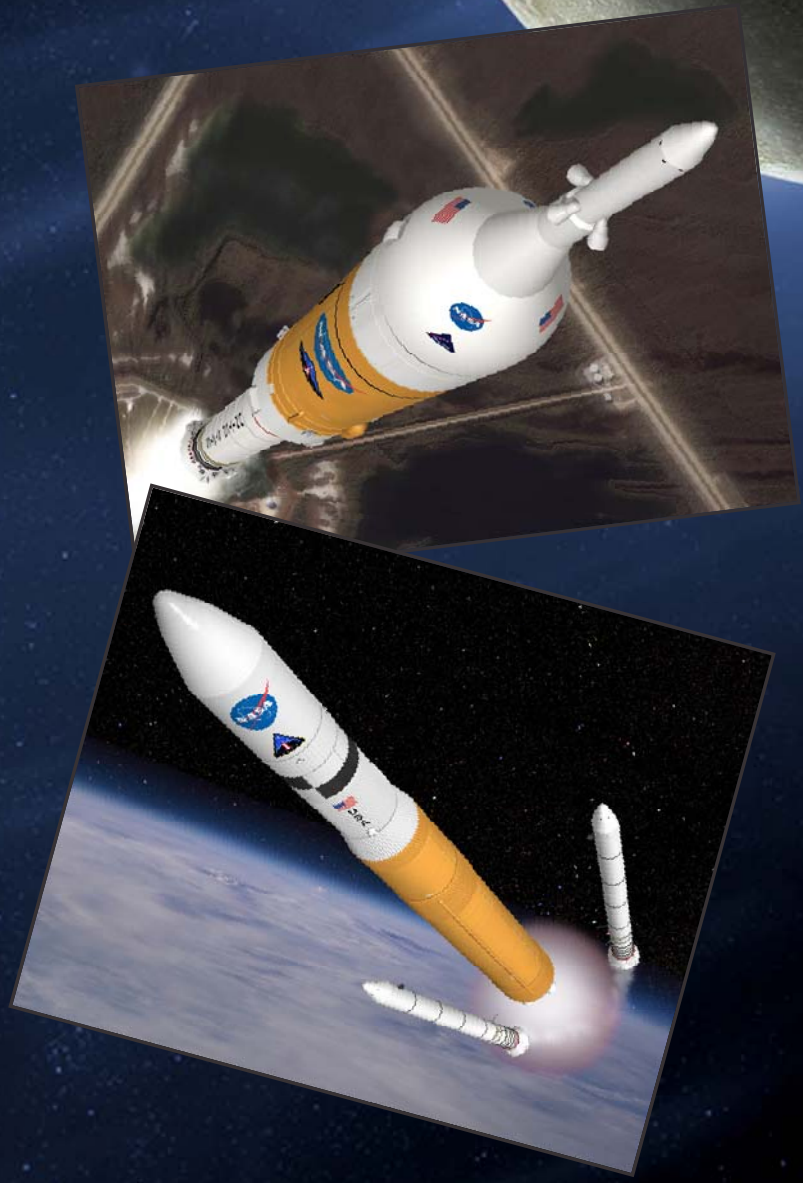
NASA Explores for Answers that Power Our Future

NASA powers inspiration that encourages future generations to explore, learn, and build a better future.

- **NASA relies on a well-educated U.S. workforce to carry out missions of scientific discovery that improve life on Earth.**
- **America's technological edge is diminishing.**
  - Fewer engineering graduates from U.S. colleges and universities
  - More engineering and science graduates in other countries
- **The global marketplace is increasingly competitive and technology-driven.**
- **Students need motivating goals and teachers with information to share.**
- **NASA continues to develop educational tools and experiences that inspire, educate, and motivate.**

Summary

- Human beings will explore the Moon, Mars, and beyond to encourage inspiration, innovation, and discovery.
- We must build beyond our current capability to ferry astronauts and cargo to low Earth orbit.
- We are starting to design and build new vehicles, using extensive lessons learned to minimize cost, technical, and schedule risks.
- Exploring the Moon will help us reach Mars and beyond.
- Team is on board and making good progress – the Ares I-X test flight is on schedule for April 2009.



www.nasa.gov/ares

Acknowledgements

- Thanks to the following MSFC persons for providing information included in this presentation:
- Joel Best, Jo Weddendorf, Tim Self, John McIntyre
- Melissa Walden
- And of course to the NASA video archives available on NASA websites